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BELLCOMM, INC.
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SUBJECT: AAP Thermal Analysis Presentation
to ML, November 12, 1968 - Case 620

DATE: November 19, 1968
FROM: J. E. Waldo

MEMORANDUM FOR FILE

The Thermal Systems Group has reviewed the thermal analysis approaches used in the six AAP spacecraft modules. The results were presented to H. T. Luskin/ML by the author on November 12, 1968, as part of the MLS response to Action Item No. 275 - Review Rationale for Using 2-sigma vs. 3-sigma for Various Phases of AAP Missions.

Complexity and uncertainty in thermal analysis require methods to establish the range of cases to be examined and the tolerance to be applied to calculate values. AAP thermal analyses by MSFC and the contractors are generally worst case; that is, all or nearly all parameters are biased to their maximum expected values to have an effect in one direction, either hot or cold. OWS passive thermal behavior is an exception; this analysis by MSFC uses worst case or "3 σ " values for the separate parameters, but their effects on net heat gain or loss are RSS'd rather than simply totaled. A copy of the viewgraphs used in this presentation is attached.

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J. E. Waldo

(NASA-CR-100207) AAP THERMAL ANALYSIS
PRESENTATION TO ML, 12 NOVEMBER 1968
(Bellcomm, Inc.) 4 p

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THERMAL ANALYSIS

INPUTS

- ORBIT AND ATTITUDE PROFILES
 - SUN ANGLE
 - S/C ATTITUDE
 - ORBIT PARAMETERS
- THERMAL CHARACTERISTICS AS FUNCTIONS OF TIME AND TEMPERATURE
 - SPECIFIC HEAT
 - ABSORPTIVITY
 - EMISSIVITY
 - CONVECTION COEFFICIENT
- PHYSICAL CONFIGURATION
 - SIZE
 - SHAPE
 - LOCATION
 - MASS (AS A FUNCTION OF TIME)
- HEAT SOURCES AS FUNCTIONS OF TIME
 - EQUIPMENT WASTE HEAT
 - METABOLIC HEAT
 - SPS AND RCS FIRINGS
 - AEROTHERMODYNAMIC
- DESIGN CRITERIA
 - MAXIMUM TEMPERATURE
 - MINIMUM TEMPERATURE

OUTPUTS

- THERMAL DATA
 - TEMPERATURE AS A FUNCTION OF POSITION AND TIME
 - HEAT FLOW AS A FUNCTION OF POSITION AND TIME
 - TOTAL THERMAL ENERGY LOSSES AND GAINS
- APPLICATIONS
 - CONDUCTIVITIES ABSORPTIVITIES, AND EMISSIVITIES
 - ELECTRICAL HEATER REQUIREMENTS
 - COOLANT FLOW RATES
 - RADIATOR AREA
 - HEAT EXCHANGER PERFORMANCE
 - INSULATION PLACEMENT

MODULE	INPUT			OUTPUT	APPLICATION
	PASSIVE	OTHER			
OWS	3 σ , SENS., RSS	WORST CASE	T	T ± 0°F	
ATM	WORST CASE	WORST CASE	T	T ± 20°F Q + 10% OR GREATER	
LM-A	WORST CASE	ACTIVE : NOMINAL MISSION : WORST CASE	T	T ± 5°F INSIDE VEHICLE T ± ?°F OUTSIDE VEHICLE	
CM-SM	WORST CASE	WORST CASE	T	T ± 18°F GENERAL TEMP. DISTR. T ± TABULATED VALUE FOR EQUIPMENT	
			T	Q ± 20% FOR HEAT SENSITIVE EQUIPMENT	
AM	WORST CASE	WORST CASE	T	Q + 100% FOR HEATER SIZING T ± 0°F	
MDA	WORST CASE	WORST CASE	T	T ± 0°F	

SUMMARY OF INTEGRATED TCS SENSITIVITY STUDY

MISSION B, $\beta = 53$

PARAMETER INVESTIGATED	NOMINAL VALUE	ASSUMED 3σ TOLERANCE	CORRESPONDING OWS HEAT LOSS DEVIATION BTU/hr.	ACCUMULATED STATISTICAL DEVIATION BTU/hr.
EARTH IR. - BTU/hr-ft ²	68.2	± 20.0	-554 +554	+ 554 - 554
ABSORPTIVITY OF SKIRT, THRUST STRUCTURE & EXTS.	NOMINAL VALUE	$\pm 10\%$	-478 +466	724 - 732
ABSORPTIVITY OF METEOROID SHIELD	0.9	$\pm .09$	-437 +442	848 - 852
EARTH ALBEDO - %	38.0	± 18.0	-434 +434	953 - 956
EMISSIVITY OF METEOROID SHIELD	0.9	$\pm .09$	+395 -437	1031 - 1052
EMISSIVITY OF SKIRT, THRUST STRUCTURE & EXTS.	NOMINAL VALUE	$\pm 10\%$	+379 -572	1099 - 1197
SOLAR CONSTANT BTU/hr. ft ²	440	± 13.2	-259 +259	1128 - 1225
EFFECTIVE EMISSIVITY ACROSS COMMON BULKHEAD	.10	+ .10 - .05	+182 -109	1144 - 1230
THERMAL CONDUCTIVITY OF INSULATION - BTU/hr-ft. °R	.02	+ .06 - .01	-156 +117	1150 - 1239
EFFECTIVE EMISSIVITY METEOROID SHIELD TO S.W.	.025	+ .025 - .010	-106 + 71	1152 - 1244
EXTERNAL FUEL TANK DOME EMISSIVITY	0.075	+ .075 - .025	+ 30 - 20	1152 - 1244
EFFECTIVE EMISSIVITY SKIRTS TO EXTENSIONS	0.05	$\pm .025$	+ 20 - 20	1152 - 1244

OWS HEAT LOAD

SOURCE	BTU/HR
● PASSIVE HEAT LOSS OR GAIN FROM SENSITIVITY ANALYSIS, MISSION $B, \beta = 53^0$	
3 σ RSS	-1152 TO 1244
3 σ SIMPLE TOTAL	-3349 TO 3582
● METABOLIC	0 TO 3000
● ELECTRICAL EQUIPMENT, 750 WATTS	0 TO 2560
SIMPLE TOTAL	-1152 TO 6804
	-3349 TO 9142

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